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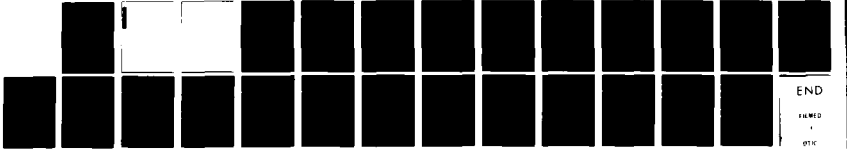

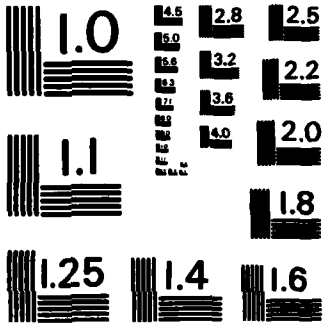

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

ADVANCED ELECTRONIC TECHNOLOGY

QUARTERLY TECHNICAL SUMMARY REPORT TO THE AIR FORCE SYSTEMS COMMAND

1 FEBRUARY — 30 APRIL 1982

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LEXINGTON MASSACHUSETTS

INTRODUCTION

This Quarterly Technical Summary covers the period 1 February through 30 April 1982. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

TABLE OF CONTENTS

DATA SYSTEMS
DIVISION 2

INTRODUCTION

This section of the report reviews progress during the period 1 February through 30 April 1982 on Data Systems. Separate reports describing other work of Division 2 are issued for the following programs:

Seismic Discrimination	ARPA/DSO
Distributed Sensor Networks	ARPA/IPTO
Defense Switched Network Technology	OSD-DCA
Digital Voice Processing	AF/ESD
Digital Voice Interoperability Program	AF/ESD
Packet Speech Systems Technology	ARPA/IPTO
Radar Signal Processing Technology	ARMY/BMDATC
Restructurable VLSI	ARPA/IPTO
Multi-Dimensional Signal Processing	AF/RADC

A.J. McLaughlin
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Associate Head

DIGITAL INTEGRATED CIRCUITS

GROUP 23

I. INTRODUCTION

Data shift registers from the test cells for the RVLSI spread-spectrum integrator have been operated up to 40 MHz, with extrapolated operation to 140 MHz at 5 V. A second lateral link with resistances in the kilohm range has been devised using polyimide which can be superimposed on wafers after fabrication by a silicon foundry. Automated procedures for detecting defective interconnect using single-probe capacitance measurements have been designed and programmed.

II. RVLSI CIRCUITS

A. Phase 0 Integrator Experiments

Measurements of the capacitance of wafer-scale interconnect lines, made on the automatic wafer prober, are used to search for opens and shorts. Programs have been written to determine the locations of defective lines providing input to the assignment and linking program on the VAX. These programs have been exercised and debugged using dummy Phase 0 wafers.

A small change in the polyimide opening in the link has been made to allow wider tolerance on alignment and focus margins across the wafer, and particularly at the outside perimeter.

Three runs of Phase 0 cells have been held at first-level metal while attempts were made to diagnose processing difficulties now thought to result from the formation of a carbonaceous film during polyimide bakeout in both links and vias. These runs are now ready to proceed using lower bakeout temperatures which should eliminate this problem.

B. RVLSI Spread-Spectrum Integrator

The previously verified integrator cell is being incorporated into the full RVLSI laser-linked system design. It is tentatively planned to provide triple, rather than double, redundancy by fitting 3 x 64 cells on a 3-in. wafer and thereby obtain greater protection against possible low cell yield.

This larger array makes it necessary to design the wafer with careful consideration for load capacitance, particularly for the three most critical circuits: (1) The 25-MHz clock bus for the Data Input shift registers should have few extra links (unused ones will probably be excised) and should run on second-level metal for low capacitance. This line is driven by buffers on the array periphery and it is straightforward to parallel devices. (2) The cell-to-cell data connection for these shift registers is driven by a buffer within the cell which has been designed to drive 10 pF, enough to jump two cells sideways and at least eight down. It should be possible to guarantee cell assignments with shorter jumps thereby providing adequate margins. (3) The output data bus is connected to all the cells through tristate drivers so that, while the required speed is modest, the capacitive load is large. The drivers in each cell are designed to drive 200 pF at the required 0.6-μs readout period.

With a single cell type, each signal line requires a track in each column or row. If groups of mirrored cells are used, then one track can serve two cells for the bus connections. In one direction, this might complicate the reticle design and lengthen cell-to-cell connections. Mirroring in the other direction is feasible and reduces data-out bus capacitance from 267 to 143 pF. Other design decisions to be made relate to stub and probe pad layout so that stub continuity is tested at wafer probe time, power distribution including fault isolation capability, and degree of interconnect redundancy.

Simulations using the assignment and linking software are under way in order to determine necessary track and link locations to provide adequate interconnect capability. We expect that mask generation can begin in June 1982.

C. FFT for Radar Applications

Wafer processing of the FFT cells has been delayed due to problems encountered in the second-level metal processing. A new via mask is being made which will allow manufacture of these test wafers without the link insulator.

A test run has been initiated in which only the interconnect layers for the wafer-scale FFT are being stepped on to a 3-in. wafer. These test wafers verify that the FFT cells will stitch together properly, and will be used in experiments to test proposed interconnect test strategies.

The software which will be used to automatically route signals for the FFT wafer continues to undergo improvements. All components are now in place and ready for use, from the entry of failed track and cell information, to the generation of move and zap commands for the laser table.

D. High-Speed Functional Testing

Since delivery of the Tektronix S 3260 VLSI tester, several functional programs for the Phase 1 integrator have been written. The Phase 1 integrator consists of two 4-bit shift registers, one for data in and the other to select output data from a 10-bit counter, and four 10-bit counters. Two programs were written using the pattern RAM (PRAM) to test each 4-bit shift register individually.

The 4-bit data shift register passed the functional test at 25 MHz at 5.0 V, and in fact operated at 40 MHz with V_{DD} = 2.5 V. This performance extrapolates to 140-MHz operation at 5.0 V. The select shift register, which is somewhat slower, ran at 20 MHz at 2.5 V and extrapolates to 70 MHz at 5.0 V.

III. RESTRUCTURABLE VLSI TECHNOLOGY

A. Laser-Formed Connections

Experiments have continued on the polysilicon lateral link structure using the automatic table to generate thousands of links successfully. The experimental data are being compiled from these runs, which were made for a number of power levels and gaps.

B. New Lateral Link Structure

A second lateral link structure has been developed which uses polyimide overlying a gap in two metal conductors. A channel burned in the polyimide is thought to leave a carbon deposit with a typical resistance of a few kilohms which would be a useable impedance level for some n-MOS circuits.

C. Laser System

Cell assignment and linking algorithms on the VAX computer have created files of commands which have successfully directed the microcomputer-controlled stepping motor system to fully connect test wafers. A second laser system is being assembled for experimental work on link development, including pyrolytic deposition of polysilicon in cooperation with Group 82.

IV. SEMICONDUCTOR PROCESSING

A. Lithography

DSW exposures of the insulating polyimide and second-level metal on the RVLSI wafers have been erratic due, we believe, to the considerable vertical excursions which exist at those levels, coupled with autofocus errors arising from nearness of image to wafer edge. Individual exposures on rows of exposures near the edges require a different focus from interior areas. The link design requires moderately tight tolerances (within 2 μm), and normal runout coupled with oversized holes due to misexposure very frequently results in the need to rework by stripping, recoating, and re-exposing the resist. A redesign of the link structures to permit wider variations arising from these factors is the most direct solution, and is being implemented. Multilevel resist techniques are also being considered to alleviate this problem. It has also been determined that we need to further increase resist exposure times in the DSW for the resist on the polyimide layer, since the polyimide absorbs the exposure wavelength very heavily and greatly reduces the back reflection from the underlying surface.

B. Dry Etching

Use of Freon 13 (CF_3Cl) for etching of polysilicon is now in place as a standard process. Work on etching PSG on polysilicon and thermox is progressing, with good results. Determinations of final etching conditions to ascertain that all the reflowed PSG has been removed from both the oxide and polysilicon remain to be done. Plasma etching of aluminum using the combination of DC bias, pure chlorine additions to the BCl_3, and argon sputter [illegible] prior to etching have resulted in etch rates of 2600 Å/min. with essentially no undercut and no resist attack.

C. Two-Level Metal and Link Processing

There has been a sudden increase in metal-to-metal via resistance and a failure of top-level metal to wet the link insulator when melted by the linking laser. Auger analysis indicates that a carbon layer exists beneath the top metal. Use of argon sputter cleaning immediately prior to second-level metal deposition eliminates the link and via problems, but it degrades the top-metal adhesion to the polyimide. The carbon layer is probably produced by an anneal after the polyimide definition. That anneal is being modified to avoid formation of the layer.

D. CMOS Processing

An apparatus was constructed to expose positive photoresist within 1.5 mm of a wafer's edge; it is used after conventional DSW exposure. We found that the resist in that region was not removed during DSW processing, and was a source of organic contamination in subsequent processes.

An investigation of nonuniform contact cut and link insulator definition revealed the presence of thin films in the resist windows which inhibited oxide etching. While the sources of the films are not yet known, their effect has been eliminated by a several-minute argon sputter etch prior to the standard etch processes.

A set of diffusion and metallization test patterns to be used in developing a twin-tub CMOS process is nearly complete. These patterns can also be adapted to n-well and CMOS on epi process experiments.

V. DEVICE THEORY

A. Nitrided Oxide

The new Auger technique* indicates that 100-Å oxide films nitrided in pure ammonia have almost uniform concentrations of the order of 50-percent nitrogen across the thickness of the film, whereas the nitrogen concentration films made in 5-percent ammonia taper down to less than 25 percent half way

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* See the Quarterly Technical Summary on Advanced Electronic Technology, Lincoln Laboratory, M.I.T. (15 February 1982).

through the film. We plan to evaluate the effect of nitrogen concentration on radiation resistance as soon as satisfactory starting oxides can be produced.

B. Electrical Properties of Thin Oxides and Nitrided Oxides

The effective Al-to-Si work function, Φ_{ms}^{eff}, has been found to be dependent on the high-tempe ature post-oxidation anneal (POA). If Φ_{ms}^{eff} is referenced to the Si intrinsic level, the commonly accepted value is 0.6 eV. We have observed values of 0.25 to 0.3 eV for thin oxides with essentially no POA, 0.55 eV for thin oxides annealed at 1100°C in N_2 for 1 h, and 0.48 eV for nitrided oxides. Further studies to determine the mechanism and establish estimates for Φ_{ms}^{eff} as a function of the POA are planned.

A process for growing thin oxides with very good interface characteristics has been developed. This will be used as a baseline for a study of interface states vs NH_3 exposure. This study is important to understand channel mobility, for radiation studies, and for bulk trapping studies.

C. Correlation of the Electronic Structure of Silicon Nitride with Its Auger Spectrum

It has been possible to correlate both the integrated Si LVV spectrum and the integrated N KVV spectrum of silicon nitride with the valence and core electronic structure of Si_3N_4, as determined from group theory and x-ray emission spectra. With this kind of a model for the valence bond structure of Si_3N_4, we intend to look for details in the Auger and x-ray Si_3N_4 spectra that could be associated with point defects in the nitride.

COMPUTER SYSTEMS

GROUP 28

During this quarter, a PASCAL cross-compiler, a cross-assembler, and a linkage editor for the Motorola M68000 microcomputer were installed on the Amdahl 470 V/8 Central Computer. These systems permit M68000 users to employ the on-line capabilities of the V/8 to develop modular programs in PASCAL, assembler, or a mixture of the two languages. Component modules are then processed through a linkage editor into a single execution module which may be tested under a simulator also residing on the V/8. Finally, after the program operates successfully, it may be down-loaded over communications lines to the target machine.

Medium-speed (4800-baud) communications with remote terminals located approximately 3 mi. from the Central Computer are being provided by a Lincoln-developed "short-haul" modem. The connecting medium is a direct run of twisted pairs being rented from the New England Telephone Company. These modems differ from typical devices of this type by providing for transmission of a timing signal, generated by the Computer, but returned to both the Computer port and the remote terminal, as though it were externally generated by the modem. Optical isolation used in the modem design provides a measure of lightning protection.

The graphics software packages DISSPLA and TELL-A-GRAF are being installed, as previously reported. During this quarter, programs and procedures have been developed to interface the packages to the Lincoln operating systems and graphics devices. A 3-day training course and other shorter presentations have been given to the Laboratory user community. The effectiveness of the system has already been demonstrated by the relative ease with which several new applications have been developed.

Other continuing activities include committee work on networking and on data-base software requirements. The former is an effort to define and guide the development of an internal network. The latter is similarly aimed at defining the Laboratory's needs in the area of data-base systems. Both activities will lead to the further extension of Central Facility services.

SOLID STATE
DIVISION 8

INTRODUCTION

This section of the report summarizes progress during the period 1 February through 30 April 1982. The Solid State Research Report for the same period describes the work of Division 8 in more detail. Funding is primarily provided by the Air Force, with additional support provided by the Army, DARPA, Navy, NASA, and DOE.

A.L. McWhorter
Head, Division 8

I. Melngailis
Associate Head

DIVISION 8 REPORTS
ON ADVANCED ELECTRONIC TECHNOLOGY

15 February through 15 May 1982

PUBLISHED REPORTS

Journal Articles

JA No.			
5209	Photovoltaic Cells	J.C.C. Fan	In Kirk-Othmer: Encyclopedia of Chemical Technology, Vol. 17, Third Edition (Wiley, New York, 1982), pp. 709-732
5269	The Permeable Base Transistor and Its Application to Logic Circuits	C.O. Bozler G.D. Alley	Proc. IEEE 70, 46 (1982)
5270	Production and Annealing of Ion-Bombardment Damage in Silicides of Pt, Pd, and Ni	B-Y. Tsaur C.H. Anderson, Jr.	J. Appl. Phys. 53, 940 (1982)
5277	Efficient Raman Frequency Conversion in Liquid Nitrogen	S.R.J. Brueck H. Kildal	IEEE J. Quantum Electron. QE-18, 310 (1982)
5279	Zone-Melting Recrystallization of Encapsulated Silicon Films on SiO_2 - Morphology and Crystallography	M.W. Geis H.I. Smith* B-Y. Tsaur J.C.C. Fan E.W. Maby* D.A. Antoniadis*	Appl. Phys. Lett. 40, 158 (1982)
5282	Stress-Enhanced Carrier Mobility in Zone Melting Recrystallized Polycrystalline Si Films on SiO_2-Coated Substrates	B-Y. Tsaur J.C.C. Fan M.W. Geis	Appl. Phys. Lett. 40, 322 (1982)
5283	Localized Laser Etching of Compound Semiconductors in Aqueous Solution	R.M. Osgood, Jr. A. Sanchez-Rubio D.J. Ehrlich V. Daneu	Appl. Phys. Lett. 40, 391 (1982)
5295	Effects of Subgrain Boundaries on Carrier Transport in Zone-Melting-Recrystallized Si Films on SiO_2-Coated Si Substrates	B-Y. Tsaur J.C.C. Fan M.W. Geis D.J. Silversmith R.W. Mountain	IEEE Electron Device Lett. EDL-3, 79 (1982)
5303	Picosecond InP Optoelectronic Switches	A.G. Foyt F.J. Leonberger R.C. Williamson	Appl. Phys. Lett. 40, 447 (1982)

* Author not at Lincoln Laboratory.

JA No.			
5308	Applications of Guided-Wave Interferometers	F.J. Leonberger	Laser Focus 18, 125 (1982)
5310	Raman Measurements of Stress in Silicon-on-Sapphire Device Structures	S.R.J. Brueck B-Y. Tsaur J.C.C. Fan D.V. Murphy T.F. Deutsch D.J. Silversmith	Appl. Phys. Lett. 40, 895 (1982)
5312	4-Bit 828-Megasample/s Electro-optic Guided-Wave Analog-to-Digital Converter	F.J. Leonberger C.E. Woodward R.A. Becker	Appl. Phys. Lett. 40, 565 (1982)
5313	Transient Annealing of Selenium-Implanted Gallium Arsenide Using a Graphite Strip Heater	R.L. Chapman J.C.C. Fan J.P. Donnelly B-Y. Tsaur	Appl. Phys. Lett. 40, 805 (1982)
5318	A Novel Technique for GaInAsP/InP Buried Heterostructure Laser Fabrication	Z.L. Liau J.N. Walpole	Appl. Phys. Lett. 40, 568 (1982)
5320	Observation of Linewidth Broadening in (GaAl)As Diode Lasers Due to Electron Number Fluctuations	D. Welford A. Mooradian	Appl. Phys. Lett. 40, 560 (1982)
5326	Efficient GaAs Solar Cells Formed by UV Laser Chemical Doping	T.F. Deutsch J.C.C. Fan D.J. Ehrlich G.W. Turner R.L. Chapman R.P. Gale	Appl. Phys. Lett. 40, 722 (1982)
5327	Output Power and Temperature Dependence of the Linewidth of Single-Frequency cw (GaAl)As Diode Lasers	D. Welford A. Mooradian	Appl. Phys. Lett. 40, 865 (1982)
5331	Optically Pumped Mode-Locked InGaAsP Lasers	R.S. Putnam* C.B. Roxlo* M.M. Salour* S.H. Groves M.C. Plonko	Appl. Phys. Lett. 40, 660 (1982)

Meeting Speeches

MS No.			
5650	The Effect of Grooves in Amorphous Substrates on the Orientation of Metal Deposits	R. Anton* H. Poppa* D.C. Flanders	J. Cryst. Growth 56, 433 (1982)

* Author not at Lincoln Laboratory.

MS No.			
5707C	Summary Abstract: Photodeposition of Metal Films with Ultraviolet Laser Light	D.J. Ehrlich R.M. Osgood, Jr. T.F. Deutsch	J. Vac. Sci. Technol. 20, 738 (1982)
5751	Experimental and Theoretical Analysis of Temperature Dependence of Wideband SAW RAC Devices on Quartz	D.M. Boroson D.E. Oates	1981 Ultrasonics Symposium Proceedings (IEEE, New York, 1981), pp. 38-43
5752	High Performance Elastic Convolver with Extended Time-Bandwidth Product	I. Yao	1981 Ultrasonics Symposium Proceedings (IEEE, New York, 1981), pp. 181-185
5755	Compact Multiple-Channel SAW Sliding-Window Spectrum Analyzer	D.R. Arsenault V.S. Dolat	1981 Ultrasonics Symposium Proceedings (IEEE, New York, 1981), pp. 220-225
5756	A SAW Tapped Delay Line with Short (15-ns) Pedestal of Delay and High (>110 dB) Feedthrough Isolation	D.E. Oates R.W. Ralston	1981 Ultrasonics Symposium Proceedings (IEEE, New York, 1981), pp. 44-47
5764	Single-Crystal GaAs Films on Amorphous Substrates by the CLEFT Process	C.O. Bozler R.W. McClelland J.P. Salerno J.C.C. Fan	J. Vac. Sci. Technol. 20, 720 (1982)

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UNPUBLISHED REPORTS

Journal Articles

JA No.			
5274	Photodeposition of Metal Films with Ultraviolet Laser Light	D.J. Ehrlich R.M. Osgood, Jr. T.F. Deutsch	Accepted by J. Vac. Sci. Technol.
5300	II-VI and IV-VI Semiconductors	A.J. Strauss	Accepted by Encyclopedia of Materials Science and Engineering (Pergamon Press, New York)
5314	Laser Remote Sensing of Hydrazine, MMH and UDMH Using a Differential-Absorption CO_2 LIDAR	N. Menyuk D.K. Killinger W.E. DeFeo	Accepted by Appl. Opt.
5316	Tantalum Oxide Capacitors for GaAs Monolithic Integrated Circuits	M.E. Elta A. Chu L.J. Mahoney R.T. Cerretani W.E. Courtney	Accepted by IEEE Electron Device Lett.

JA No.			
5321	Fabrication of Through-Wafer Via Conductors in Si by Laser Photochemical Processing	D.J. Ehrlich D.J. Silversmith R.W. Mountain J.Y. Tsao	Accepted by IEEE Trans. Components, Hybrids, and Manufacturing Technology
5325	An Integrated Optical Temperature Sensor	L.M. Johnson F.J. Leonberger G.W. Pratt, Jr.*	Accepted by Appl. Phys. Lett.
5335	Pulse-Pumped Operation of Divalent Transition-Metal Lasers	P.F. Moulton	Accepted by IEEE J. Quantum Electron.
5360	Speculations on Solid State Tunable Lasers	P.F. Moulton	Accepted by IEEE J. Quantum Electron. (Editorial Section)

Meeting Speeches†

MS No.			
5609C	Advances in Divalent Transition-Metal Lasers	P.F. Moulton	Seminar, Boston College, Newton, Massachusetts, 21 April 1982
5632C	InP Optoelectronic Mixers	A.G. Foyt	United Technologies Research Center, E. Hartford, Connecticut, 26 March 1982
5707F	Ultraviolet-Laser Photodeposition	D.J. Ehrlich J.Y. Tsao	Workshop on Diamond-Like Carbon Films, Albuquerque, New Mexico, 19-20 April 1982
5899A	Raman Scattering as a Probe of Thin-Films	S.R.J. Brueck	
5707G	Laser Photodeposition of Thin Film Structures	D.J. Ehrlich	OSA/IEEE Regional Mtg., San Jose, California, 21 April 1982
5726A	Current Status of Thin-Film GaAs Solar Cells	J.C.C. Fan C.O. Bozler R.W. McClelland	Space Photovoltaic Research and Technology Conf., Cleveland, Ohio, 20-22 April 1982
5763A	Analysis of the Electronic Behavior of Grain Boundaries in GaAs	J.P. Salerno	American Association for Crystal Growth, New England Section, Cambridge, Massachusetts, 16 February 1982
5866	MNOS/CCD Nonvolatile Analog Memory	R.S. Withers D.J. Silversmith R.W. Mountain	IEEE Nonvolatile Semiconductor Memory Workshop, Monterey, California, 7-10 March 1982

* Author not at Lincoln Laboratory.
† Titles of Meeting Speeches are listed for information only. No copies are available for distribution.

MS No.			
5871	Picosecond InP Optoelectronic Switches	A.G. Foyt F.J. Leonberger R.C. Williamson	CLEO '82, Phoenix, Arizona, 14-16 April 1982
5881	High-Speed UV- and X-Ray-Sensitive InP Photoconductive Detectors	T.F. Deutsch F.J. Leonberger A.G. Foyt	
5883A	4-Bit 828-Megasample/s Guided-Wave Electrooptic Analog-to-Digital Converter	F.J. Leonberger C.E. Woodward R.A. Becker	
5888	Spatial-Period-Division Using an ArF Laser	A.M. Hawryluk* H.I. Smith* R.M. Osgood, Jr.* D.J. Ehrlich	
5899	Laser Raman Scattering as a Probe of Si Device Structures	S.R.J. Brueck B-Y. Tsaur D.V. Murphy J.C.C. Fan T.F. Deutsch D.J. Silversmith	
5910A	Fundamental Line Broadening Mechanisms of Single-Frequency CW (GaAl)As Diode Lasers	D. Welford A. Mooradian	
6013	Review of Current Submillimeter Laser Applications	H.R. Fetterman	
6018	Laser Photodeposited Metal Films: Stimulated Surface Plasma Waves and Growth of Grating Structures	S.R.J. Brueck D.J. Ehrlich	
5886	Hybrid Analog/Digital Signal Processing	J.H. Cafarella	8th Strategic Space Symp., Monterey, California, 1-5 March 1982
5896	Raman Spectra of Ultrathin Si Films	D.V. Murphy S.R.J. Brueck D.D. Rathman	American Physical Society Mtg., Dallas, Texas, 8-12 March 1982
5913	Dry Etching of Gate Recesses for GaAs MESFETs	L.J. Mahoney A. Chu G.A. Lincoln M.W. Geis N.N. Efremow	Workshop on Compound Semiconductor Microwave Materials and Devices, Scottsdale, Arizona, 21-23 February 1982

*Author not at Lincoln Laboratory.

MS No.			
5914	Fabrication of Surface Relief Structures for Permeable Base Transistors	B.A. Vojak K.B. Nichols G.A. Lincoln M.W. Geis R.W. McClelland D.C. Flanders J.P. Salerno	Workshop on Compound Semiconductor Microwave Materials and Devices, Scottsdale, Arizona, 21-23 February 1982
5929	IR Detectors: Heterodyne and Direct	D.L. Spears	Workshop on Optical and Laser Remote Sensing, Monterey, California, 9-11 February 1982
5975	Nonlinear Optics with Simple Molecular Liquids	S.R.J. Brueck	Seminar, University of Toronto, Ontario, Canada, 30 March 1982
6003	Some Recent Progress in InGaAsP Lasers	J.N. Walpole	Optics and Quantum Electronics Seminar, M.I.T., 10 March 1982
6007	Electrooptical Devices for GHz Sampling and A/D Conversion	F.J. Leonberger	Seminar, Moore School of Engineering, University of Pennsylvania, 25 March 1982
6011	Surface Wave Technology	D.E. Oates	Ultrasonics Industry Association Technical Symp., New York, 31 March 1982
6029	Ion-Beam Mixing	B-Y. Tsaur	Symp. on Surface Modification of Materials, Oak Ridge, Tennessee, 16 April 1982

SOLID STATE

DIVISION 8

I. SOLID STATE DEVICE RESEARCH

The excess noise factor as a function of multiplication has been determined in p^+-n-n^+ inverted-mesa InP avalanche photodiodes. The noise factor is below 3 for multiplication values less than 10, but rises rapidly for higher multiplication as was previously observed in GaInAsP/InP diodes. The ratio of the ionization coefficients determined from noise data is shown to depend on the model used.

GaInAsP/InP double-heterostructure laser wafers were grown, fabricated into lasers, and evaluated. By using nearly optimized growth conditions, a high yield of lasers with low threshold current density J_{th} emitting at 1.3 μm wavelength was obtained. Accurate measurements of the active-layer thicknesses d yielded J_{th}/d values of 5 to 4.5 kA/cm^2-μm as d increased from 0.45 to 1.1 μm.

Be-implanted broad-area GaInAsP/InP double-heterostructure laser diodes operating at 1.3 μm have been fabricated which have threshold current densities comparable to those prepared using conventional Zn doping during the epitaxial growth of the InP cap layer. The lowest threshold current density measured in an implanted laser was 1.2 kA/cm^2, corresponding to J_{th}/d of 4.2 kA/cm^2-μm. A more typical lower value of J_{th} on wafers with thin active layers (0.25 to 0.35 μm) was 2.0 kA/cm^2.

The technology for fabricating laser diodes, detectors, and optical waveguides in GaInAsP/InP epitaxial wafers requires the use of suitable etching techniques for providing smooth, damage-free surfaces for precision pattern geometries and for the preferential and reproducible removal of specific layers. It has been found that a 1 H_2SO_4:1 H_2O_2:10 H_2O room-temperature solution etches (100) $Ga_{0.27}In_{0.73}As_{0.03}P_{0.37}$ (λ = 1.3 μm) at a very constant etch rate of 1000 Å/min. Various other ratios of H_2SO_4:H_2O_2:H_2O should prove useful as slow selective etches for GaInAsP in a variety of applications.

II. QUANTUM ELECTRONICS

The limitations of signal averaging due to temporal correlation in laser remote-sensing measurements have been determined experimentally. The results are in excellent agreement with the theoretically predicted improvement in measurement accuracy achievable by signal-averaging partially correlated data. With temporal correlations, the improvement in the standard deviation that can be obtained by signal-averaging is limited, regardless of the number of pulses averaged.

The submicrometer ripple structures observed in UV-laser photodeposited metal films have been shown to arise from stimulated surface plasma-wave scattering processes. This is the first observation of a stimulated scattering process involving surface electromagnetic waves.

The response of Fe-doped InP photoconductive detectors to ~9-keV x-ray pulses has been examined, and device risetimes <90 ps have been measured. The devices are the fastest solid-state x-ray detectors reported to date; they are simple, compact, and could be integrated into array structures.

III. MATERIALS RESEARCH

Single-crystal GaAs layers have been obtained by means of lateral epitaxial overgrowth seeded within stripe openings in a SiO_2 mask over GaAs layers grown on Ge-coated Si substrates. The dislocation density in the laterally overgrown layers is less than 10^4 cm^{-2}, compared with 10^7 to 10^8 cm^{-2} for the layers grown directly on the Ge/Si substrates, indicating that the overgrown layers will be useful for solar cells and other device applications.

A study has been made of the effects of ionizing radiation on the electrical characteristics of n-channel MOSFETs fabricated in zone-melting-recrystallized Si films on SiO_2-coated Si substrates. These effects can be largely suppressed by applying a moderate negative bias to the substrates during irradiation and device operation, so that these devices are promising components for radiation-hardened circuits.

A scaled-up graphite strip-heater system has been constructed for routine zone-melting recrystallization of Si films on SiO_2-coated Si substrates. Almost all large-angle grain boundaries have been eliminated by means of seeded recrystallization, which is accomplished by scribing a stripe opening that extends through the Si and SiO_2 films to the Si wafer, but the films still contain large numbers of low-angle subgrain boundaries.

IV. MICROELECTRONICS

The design of a charge-coupled-device time-integrating correlator for use with the Global Positioning System P-code has been completed. An input structure has been chosen which generates the required complementary charge packets and is not susceptible to a CW jammer at the carrier frequency. The design of the charge integrator incorporates a skimming process which reduces the amount of charge transferred to the output register without introducing temporal noise onto the signal.

A two-stage monolithic IF amplifier incorporating a reactively sputtered Ta_2O_5 capacitor has been fabricated. The capacitor is a sequentially sputtered composite layer structure consisting of Au, Ta, Ta_2O_5, Ta and Au, and has a unit area capacitance of 1500 pF/mm^2. The amplifiers exhibit a gain of 17.5 ± 1.0 dB for 1.2 to 2.6 GHz and a minimum noise figure of ~2.7 dB, with an associated gain of 17.5 dB at 1.7 GHz.

Response of GaAs FETs in millimeter-wave and optical-heterodyne experiments has been obtained at frequencies above the frequency of unity current gain f_T. In the mixing of two visible lasers, beat frequencies as high as 300 GHz have been observed. These high IFs were downconverted to microwave frequencies by radiatively coupling millimeter-wave local oscillators into the gate region.

The effects on silicon surfaces of reactive ion etching with CF_4, CHF_3, $SiCl_4$, or Cl_2 and ion milling with Ar were investigated by measurements on MOS structures fabricated on etched surfaces, and by Secco etching to determine the extent of oxidation-induced stacking faults. Chlorine-based

gases produced less damage during etching than fluorine-based gases, and surfaces etched in CHF_3 provided a better $Si-SiO_2$ interface than those etched by CF_4. The density of oxidation-induced stacking faults after Ar ion milling was found to increase with ion energy.

V. ANALOG DEVICE TECHNOLOGY

Superconductive tapped delay lines have been configured as upchirp and downchirp filters, with bandwidths of 2 GHz and dispersion times of 27 ns. Also, pulse compression has been demonstrated with a matched pair of these unweighted filters. The compressed pulse output, obtained in a preliminary experiment using 800 MHz of bandwidth and 11 ns of delay, closely matches the results obtained from an accurate theoretical model.

An analytical model developed to explain the temperature dependence of surface-acoustic-wave reflective-array devices fabricated on anisotropic substrates has been applied to ST-quartz devices. The calculated results were in excellent agreement with measurements of the temperature dependence of chirp slope, group delay, and insertion loss for dispersive filters fabricated on this cut. Devices fabricated on both isotropic-RAC-cut and ST-cut quartz were found to be temperature stable, with a stability about 100 times better than that of devices fabricated on lithium niobate.

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